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MEASUREMENT OF THE AMOUNT OF WATER VAPOR CONTAINED IN THE ATMOSPHERE OF PLANET MARS

by

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[6]

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MEASUREMENT OF THE AMOUNT OF WATER VAPOR CONTAINED IN THE ATMOSPHERE OF PLANET MARS *

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by M. Audouin Dollfus (Paris-Meudon Obs.)

ABSTRACT

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Comparing the intensity of the H_2O 1.4 μ line on Mars, the Moon and the stars, the Author established, by using a photometric method under ideal high-altitude winter conditions, that Planet Mars containes $2 \cdot 10^{-2}$ g/cm^2 of H_2O in the state of vapor. Assumed entirely liquefied, this amount of martian water would constitute on the ground a layer 0.2 mm thick.

UNCL. AUTHOR

* * *

Polar caps of Planet Mars polarize the light in the manner of tiny water ice crystals. These were reproduced in laboratory conditions by reconstituting martian physical features [1]. Light is also polarized by martian clouds just as it is by terrestrial cirrus clouds [2]. The infrared reflecting power of polar caps is compatible with water white frost [3]. It is thus certain that the atmosphere of Mars contains water vapor, which, being very mobile, must move about seasonably and alternately from one hemisphere to the other [2, 4].

But to-date all attempts to seek the spectroscopic proof of existence of water vapor have failed (see [3, 5, 6, 7].

* Mesure de la quantité de vapeur d'eau contenue dans l'atmosphère de la planète Mars.-

For lack of data, speculative estimates diverged as follows: $6 \cdot 10^{-4}$ g/cm^2 (Kuiper, 1948, [3], $\leqslant 4 \cdot 10^{-2}$ g/cm^2 (Hess, 1948, [8]), $1 \cdot 10^{-2}$ g/cm^2 (de Vaucouleurs [9]), $3 \cdot 10^{-3}$ g/cm^2 (Goody, 1957 [10]), from $4 \cdot 10^{-2}$ to $4 \cdot 10^{-3}$ g/cm^2 (H. C. Urey, 1959 [11]). The observations conducted in a free balloon led me to the estimate of $2.5 \cdot 10^{-2}$ g/cm^2 [12].

METHOD. - In January 1963 Planet Mars had $+19^{\circ}$ for declination and it was high in the sky, while the low temperature of the winter left little water vapor in our atmosphere. The very-highly located Scientific Station of Jungfraujoch (3,600 m in the Alps) is above the atmospheric layers containing most of the terrestrial water. There the temperature often drops to -25° C, and the humidity – below 20%. The atmosphere contains then above the place of observation only a few centigrams of water per cm^2. Such conditions allow the searching of water vapor in planetary atmospheres by a simple photometric comparison of telluric bands between the heavenly body and the comparison light provided by the Sun, the Moon and certain stars. It is thus appropriate to select non-saturated spectral bands along visual rays under the given conditions of observation. The 1.15 and 1.40 μ bands are suitable for that purpose, the latter, more intense, being saturated for 10^{-1} g/cm^2, corresponding to the maximum sensitivity of PbS cells.

DEVICE. - The 1.4 μ band is isolated by a Lyot-type polarizing filter with four quartz plates of 0.4 μ half-width, centered on 1,385 μ. I previously descibed a device utilizing such filters to measure the spectral band intensity [12, 13]. The light condenser is a reflecting telescope, 50 cm in diameter, with a f/I aperture. The Cassegrain combination gives it a 3.5 m focal length. Owing to the half-wave blade modulator recently described [14], the filter transmits the spectral band to be measured and two lateral bands alternately and rapidly. A Wollaston birefringent prism is substituted for the polarizer at the output. It emits two orthogonally polarized and opposite-phase modulated beams, which illuminate the two halves of the photocathode of the PbS cell, especially prepared in M, Lallemand's laboratory with an additional median electrode directly connected to amplifier output resistance. When cooled by means of solid carbon dioxide, the cell promotes natural fluctuations of 10^{-11}W in 1 s.

The signal emitted by the 1.4 μ band of H_2O is compensated by the interposition of a quartz plate between the two mobile polarizers, creating a ribbed spectrum of adjustable contrast, framing the band to be measured.

The observer ensures a precise compensation thanks to the prolonged integration of the residual signal with the help of a fluxmeter. The sensitivity increases as the heavenly body's brightness and as the square root of the integration duration. A dozen of 60 s-integrations on Planet Mars, of +0.7 magnitude, provide the tenor in water with a precision to $\pm 8 \cdot 10^{-3}$ g/cm^2.

The indications of the compensator are converted into tenor in water by previous calibration, obtained by aiming at light sources at increasing distances, between 3 and 300 m, knowing the temperature and humidity of the air.

OBSERVATIONS. - I stayed at Jŭngfraŭjoch during the whole month of January 1963, accompanied by M. G. Spaak. The light azimuthal telescope, easily transportable, was installed during every favorable night on the terrace of the "Sphinx" after clearing the snow and a strong packing so as to minimize the danger of high wind. A hot air outlet protected the electronic device from the cold, helping at the same time the hands of the operator. We watched the water tenor in the terrestrial atmosphere by taking readings on the Moon or on "Betelgeuse" at different zenithal distances. We determined the resulting signal in the direction of Planet Mars.

A series of measurements on the Planet itself were interposed. Five determinations collected on the 15, 16, 21, 23 and 28 Jan.1963, have given each time a signal on Mars exceeding that attributed to terrestrial water vapor. The difference was worth three times the sensitivity threshold. Thus water vapor from Mars did exert its effect upon the device.

During the most favorable night of all, the terrestrial water along the visual ray descended to $4.2 \cdot 10^{-2}$ g/cm^2. Two series of measurements on Mars gave $7.6 \cdot 10^{-2}$ g/cm^2, the difference of $3.4 \cdot 10^{-2} \pm 1 \cdot 10^{-2}$ g/cm^2 being due to water vapor on the Planet. Solar light crosses twice the martian atmosphere. An oblique trajectory at the limb of the disk adds to the course. The integration shows that in order to obtain the humidity on the planet, the preceding value, say $8.5 \cdot 10^{-3}$g/cm^2 must be divided by 4.

The device was calibrated at the terrestrial atmospheric pressure. The martian pressure, 10 times lower, diminishes the intensity of the spectral bands by about the factor of 2.3 [15]. Upon correction, the quantity of water vapor found for the whole of martian atmosphere is worth $2 \cdot 10^{-2}$ g/cm^2. If we assume it to be entirely in liquid form, martian water would form on the ground a layer 0.2 mm thick.

**** THE END ****

Translated by ANDRE L. BRICHANT
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REFERENCES

[1]. A. DOLLFUS. Comptes-Rendus, 233, 467, 1951.

[2]. A. DOLLFUS. These de Doctorat, 1955.
Supl. Ann.Astrophysique, Plan. and Satellites, ch.9, Univ.Chicago Press, 1961.

[3]. G. P. KUIPER. The Atmosphere of the Earth and Planets.- Univ.of Chicago Press, 1948.

[4]. A. DOLLFUS. Colloque de Liége (Mém.Soc.Roy. Liége, 18)

[5] VERY. Lowell Obs.Bull. 1, No.17, 1909.

[6]. ADAMS, DUNHAM, Ap.J., 79, p.308, 1934.

[7]. C. C. KRIESS, Ibid., 126, p. 574, 1957.

[8]. S. HESS, P. A. S. P., 60, p.286, 1948.

[9]. G. DE VAUCOULEURS. Physique de la Planète Mars, Alb.Michel, p.249,

[10]. GOODY, Weather, 12, p.3, 1957.

[11]. H. C. UREY. Hand. Physik, 52, p.398, 1959.

[12]. A. DOLLFUS. Comptes-Rendus, 239, p.954, 1954.

[13]. A. DOLLFUS, L'Astronomie, Sept.1959

[14]. A. DOLLFUS, Comptes-Rendus, 256, p.120, 1963.

[15]. J. N. HOWARD, L. BURCH AND D. WILLIAMS, Geophys.Res. No. 40, 1955.

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